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SEAL MODIFICATION FOR HIGH PRESSURE AND HIGH TEMPERATURE TRIAXIAL TEST VESSEL

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SEAL MODIFICATION FOR HIGH PRESSURE AND HIGH TEMPERATURE
TRIAXIAL TEST VESSEL

by

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SUMMARY

High temperature and high pressure triaxial vessels are standard equipment in laboratories assessing the behaviour of rocks under elevated temperatures and confining pressures such as required for underground nuclear waste storage.

The CANMET Mining Research Laboratories possess such a triaxial vessel and after initial testing it became evident that the sealing mechanism supplied by the manufacturer required considerable maintenance. The testing procedure was difficult and laborious and extreme caution had to be used to obtain valid test results. The sealing mechanism was modified by installing a hard soft-seal combination. The modification has been very successful and the reliability of the test results has increased. The operational costs have been reduced significantly.

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MODIFICATION DU JOINT D'ÉTANCHÉITÉ DU
RÉCIPIENT D'ESSAI TRIAXIAL SOUS HAUTE
PRESSION ET À HAUTE TEMPÉRATURE

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RÉSUMÉ

Les récipients d'essai triaxiaux sous haute pression et à haute température font partie du matériel standard des laboratoires d'étude de la tenue des roches aux hautes températures et pressions de confinement requises pour le stockage sous terre des déchets nucléaires.

Les Laboratoires de recherche minière du CANMET possèdent un tel récipient triaxial. Après quelques essais initiaux, il est manifestement apparu que le joint d'étanchéité fourni par le fabricant nécessitait beaucoup d'entretien. Le mode opératoire était d'exécution difficile et il fallait travailler soigneusement et faire preuve d'une prudence extrême pour obtenir des résultats valables. Le joint a donc été remplacé par un joint mixte en dur et en mou. Le nouveau joint donne entière satisfaction et la fiabilité des résultats d'essai a été accrue. Son bon fonctionnement permet d'abaisser considérablement les frais d'exploitation.

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INTRODUCTION

The assessment of the behaviour of rocks under high temperatures and high pressures requires a special triaxial test vessel. Such a vessel was purchased from Pressure Systems Research by the Mineral Research Laboratories in 1978. With this equipment it is possible to measure strain and permeability at high confining pressures and temperatures. The testing procedures are relatively standard in regard to specimen preparation, but the sealing system on the vessel caused problems and it was difficult to meet requirements of the testing program with about 100 tests per year.

HIGH PRESSURE AND HIGH TEMPERATURE SEAL

Original Sealing System

The sealing is accomplished by deforming a mild steel ring against the vessel and piston walls as shown in Fig. 1-A.

Setting of the seal is obtained by removing the seal restraint nut and forcing the hardened steel ring down, with a special steel tube. A force of 222.4 kN (50 000 lb) is required, to deform the steel sealing ring sufficiently so it will touch the piston OD and the wall of the vessel. The seal restraint nut is put in place and the whole assembly moved into the hydraulic press. The piston movement is restrained with the press and confinement pressure is applied up to a maximum of 69 MPa (10 000 psi). If there is no leakage, the heating cycle can be started. If there is leakage the whole process has to be repeated with a larger force for setting the seal 266.9 kN (60 000 lb) or the sealing ring has to be replaced. The piston and sealing ring can only be removed with hydraulic aids.

Because of friction losses between seal and piston the determination of the load actually acting on the sample becomes very difficult. To move the piston, up to 44.5 kN (10 000 lbs) have been required. A differential transducer has been used in the bottom of the vessel as a load sensor. However, the output voltage was erratic because of mechanical linkages.

New Seal Development

A seal modification with a U cup neoprene seal was successful but the temperature limits were too low. A search of sealing materials turned up a product called Garlock Graph-lock Tape (1) which met the need of low frictional loss and high temperature capability.

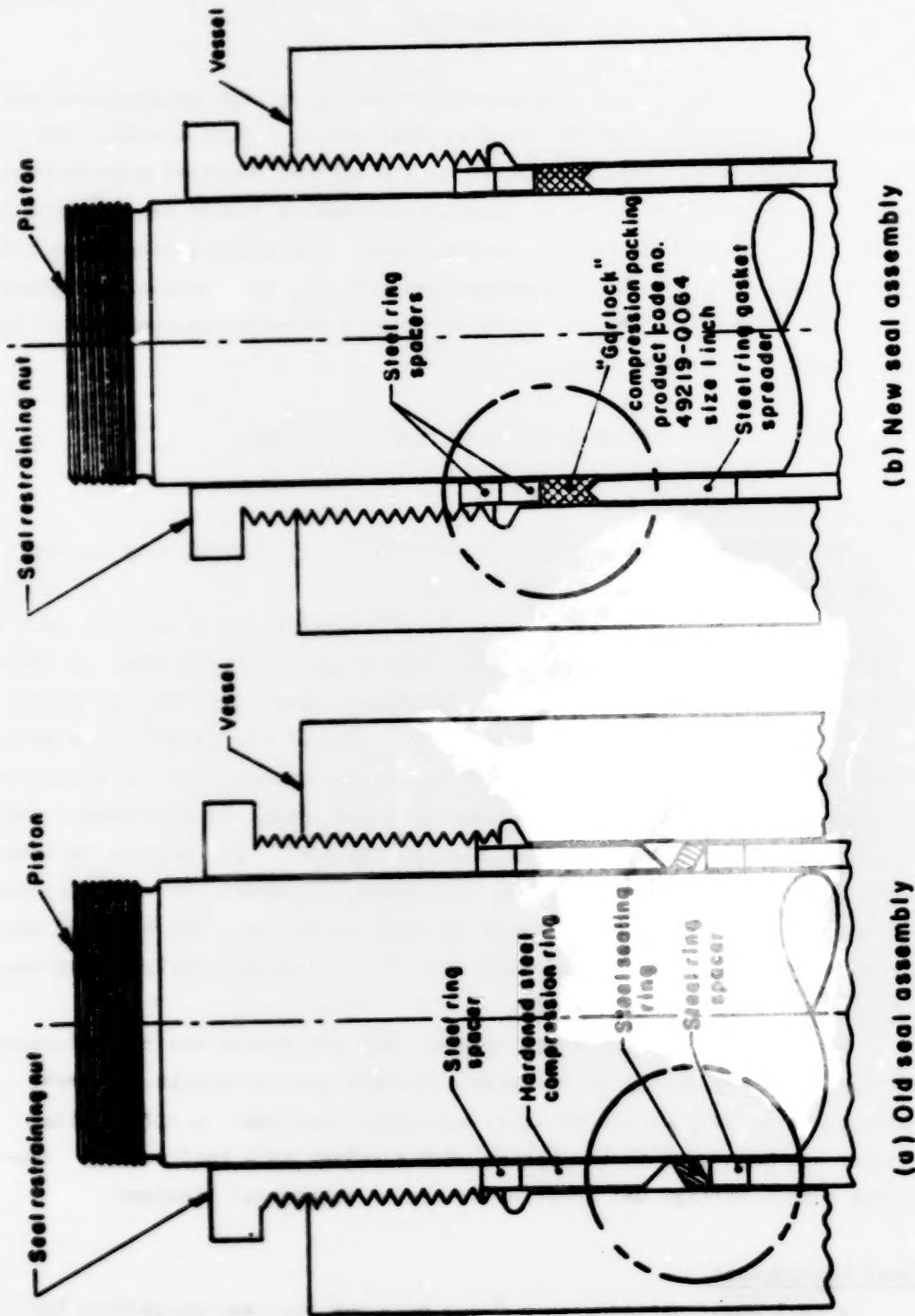


Fig. 1 - Seal assembly for high pressure and temperature compression vessel
(A before, B after modification)

After some initial experimentation the following procedure proved successful. A mild steel ring is inserted into the seal cavity (tolerances are not too critical) which has a triangular top crosssection (Fig. 1B). Garlock compression packing, 1" wrapped around the piston to a thickness of slightly under the inside diameter of the vessel. A square shaped ring is placed on top of the Garlock material. The steel ring is then pressed down with a force of 22.2-35.6 kN (5000-8000 lbs). The packing material deforms exactly to the shape of the available space. The seal restraint nut is then inserted and tightened. The confinement pressure is applied to the appropriate level.

If leakage occurs, only the restraint nut needs to be tightened. This arrangement has worked very well and up to 50 tests have been run successfully with one seal. The piston scoring is eliminated and a need to regrind or to replace the piston has not yet arisen. The piston surface has become highly polished, which reduces friction. Frictional losses are reduced to 2 kN (450 lbs) which is insignificant in relation to the total applied force. This eliminated the need to rely on a load cell to determine specimen loading.

The seal modification resulted not only in more reliable data but provided also a reduction of costs per test as shown in Table 1.

Table 1 - Cost comparison

Material	Old seal	Per test	New seal	per test
	<u>\$</u>	<u>\$</u>	<u>\$</u>	<u>\$</u>
Sealing ring (1 per 2 tests)	200	100.00	-	-
Garlock tape (1 per 25 tests)	-	-	27.00	1.07
Replacement piston (1 per 30 tests)	1250	41.70	-	-
Regrounding of piston (1 per 10 tests)	250	25.00	-	-
Seating of seal/piston assembly				
(1 per test)	2 h*	50.00	-	-
Vessel assembly (1 per test)	1 h	<u>25.00</u>	-	<u>25.00</u>
		241.70		26.07

*Labour at \$25 per h

On the basis of 100 tests, cost savings amount to \$21,563.00 and the reliability of test results has been improved considerably.

REFERENCES

1. Commercial literature

Garlock
Mechanical Packing Division
Compression Packing
Garlock of Canada Ltd.
Toronto, Ontario M8Z 2H3

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